VARIABLE AREA NOZZLE FOR GAS TURBINE ENGINES DRIVEN BY SHAPE MEMORY ALLOY ACTUATORS

The invention described herein was made in the performance of work under NASA Contract No. NS3-98005, and is subject to the provisions of Section 305 of the national Aeronautics and Space Act of 1958, as amended (42 U.S.C. 2457).

CROSS-REFERENCE TO RELATED APPLICATION

This application relates to an application entitled "Shape Memory Alloy Bundles and Actuators", having an Application Ser. No. 09/517,938 , filed on the same date herewith and assigned to a common assignee.

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates to gas turbine engines and, more particularly, to variable area nozzles driven by shape memory alloy actuators therefor.

2. Background Art

Conventional gas turbine engines include a fan section and a core engine with the fan section having a larger outer diameter than that of the core engine. The fan section and the core engine are disposed sequentially about a longitudinal axis and are enclosed in a nacelle. An annular path of primary airflow passes through the fan section and the core engine to generate primary thrust. An annular path of duct or fan flow, disposed radially outward of the primary airflow path, passes through the fan section and exits through a fan nozzle to generate fan thrust.

The fan nozzles of conventional gas turbine engines have fixed geometry. The fixed geometry fan nozzles must be suitable for take-off and landing conditions as well as for cruise conditions. However, the requirements for take-off and landing conditions are different from requirements for the cruise condition. For cruise conditions, it is desirable to have a smaller diameter fan nozzle for increasing cruise performance and for maximizing fuel efficiency, whereas, for take-off and landing conditions, smaller diameter fan nozzles may cause an engine stall. Therefore, in many conventional engines, the cruise performance and fuel efficiency are often compromised to ensure safety of the gas turbine engine at take-off and landing.

Some gas turbine engines have implemented variable area nozzles. The variable area nozzles have the ability of having a smaller fan exit nozzle diameter during cruise conditions and a larger fan exit nozzle diameter during take-off and landing conditions. The existing variable area nozzles are either hydraulically or pneumatically actuated and result in complex mechanisms that require extensive maintenance. Most commercial aircraft prefer to avoid additional maintenance. Furthermore, the existing variable area nozzle mechanisms add significant weight to the engine. As is well known in the art, the extra weight adversely effects the overall performance of the aircraft. The additional weight reduces aircraft range and can result in additional fuel consumption for operation of the engine. Therefore, it is critical in gas turbine engine fabrication to avoid a weight increase, since the weight increase resulting from the addition of a variable area nozzle typically negates benefits gained from improved fuel efficiency resulting from the reduced diameter of the variable area nozzle during cruise conditions. Thus, although variable area nozzles have been introduced into some gas turbine engines, the use of existing variable area nozzles on most aircraft is not practical.

Therefore, it is desirable to develop a variable area nozzle that does not require extensive maintenance and does not add significant weight to the gas turbine engine.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a gas turbine engine with a variable area nozzle that does not significantly increase the overall weight of the gas turbine engine and does not require extensive maintenance.

According to the present invention, a gas turbine engine includes a variable area nozzle having a plurality of flaps actuated by a plurality of actuating mechanisms driven by shape memory alloy ("SMA") actuators to vary fan exit nozzle area. Each actuating mechanism includes a four bar linkage with a drive arm engaged by the SMA actuator. The SMA actuator has a deformed shape in its martensitic state and a parent shape in its austenitic state. The SMA actuator is heated to transform from martensitic state to austenitic state generating a force output to actuate the flaps. The SMA actuator is allowed to cool or is actively cooled to transform from austenitic state to martensitic state.

The variable area nozzle also includes a plurality of return mechanisms deforming the SMA actuator when the SMA actuator is in its martensitic state. In one embodiment of the present invention, the return mechanism is spring actuated. In another embodiment of the present invention, the return mechanism comprises a secondary SMA actuator engaging the drive arm of the four bar linkage.

According to one aspect of the present invention, the SMA actuator engages a four bar linkage to generate a sweeping motion. Depending on the configuration of the four bar linkage, the motion can be either parallel or non-parallel.

One major advantage of the present invention is that the SMA actuated variable area nozzle does not require complex mechanisms necessitating extensive maintenance.

Another major advantage of the present invention is that the SMA actuated variable area nozzle does not add significant weight to the engine, thereby improving the benefits associated with the overall fuel efficiency increase of the gas turbine engine.

The foregoing and other advantages of the present invention become more apparent in light of the following detailed description of the exemplary embodiments thereof, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially broken away, simplified representation of a gas turbine engine with a variable area nozzle;

FIG. **2** is an enlarged, simplified representation of the variable area nozzle of FIG. **1** in the diverged position, driven by a SMA actuator, according to the present invention;

FIG. **3** is a simplified representation of the variable area nozzle of FIG. **2** in the converged position;

FIG. **4** is an enlarged, simplified representation of a four bar linkage of the variable area nozzle of FIG. **2** driven by the SMA actuator;

FIG. **5** is an enlarged, fragmentary, perspective view of the SMA actuator of FIG. **4**;

FIG. **6** is a simplified, side elevation of the four bar linkage engaged by the SMA actuator of FIG. **4** taken along line **6**—**6**;